

EXHIBIT 94

**What Voters are Asked to Verify Affects Ballot Verification: A Quantitative Analysis of
Voters' Memories of their Ballots***

Richard A. DeMillo and Robert S. Kadel

Georgia Institute of Technology

and

Marilyn R. Marks

Coalition for Good Governance

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ABSTRACT

As a new generation of voting system technology is deployed in response to concerns about the security of American election infrastructure, the role of voter verification of paper audit trails (VVPAT) has re-emerged as central to ensuring election integrity. A critical step in many electronic voting systems relies on the ability of a voter to carry out what seems at first blush like a simple task: review a computer-generated record of ballot choices made moments before to verify that those choices have been fully and accurately recorded. Prior studies have not addressed what appears to us to be the fundamental question to be resolved if VVPAT is to be a cornerstone of voting technology: can electors verify their votes by reviewing a paper ballot summary? If so, then the paper records are relatively secure evidence of voter intent that can be used to conduct audits and recounts. If not, then adversaries who can compromise voting systems can change votes with impunity. The experiments described in this paper, conducted in 2018 during the May 1 and August 2 Tennessee primary elections, suggest that the answer may be “No.”

In asking this question, we are not concerned so much about the practical problems associated with VVPAT as whether there are fundamental cognitive limitations on the act of verification itself. We present preliminary evidence suggesting that, in actual polling place settings, most voters will not attempt to verify paper ballot summary cards, even when directed to do so. Furthermore, polling place exit interviews of voters who attempt to review their ballots reveal that a statistically significant fraction is unable to recall important details of ballots cast only moments before. Voters either fail to recognize errors in ballots presented to them for verification or fail to recognize that the ballots presented for verification were not the ones they cast. These results are broadly consistent with other recent studies that cast doubt on the

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reliability and accuracy of memory recall and are evidence of voter memory errors that would make a verified ballot summary card impossible to rely upon as a reliable source record for a post-election audit.

This study differs from prior studies on VVPATs used with DRE (“Direct Recording Electronic”) machines, as this study is limited to more recent electronic ballot marking device (“BMD”) technology. Such technology involves a voter making choices on a touchscreen machine that produces a ballot summary card (not the full ballot contents). The ballot summary card is inserted into a separate mark sense scanner to complete the vote casting process. A consequence of the results presented here is that voters who cast ballots on compromised ballot marking devices that change votes but who have not securely registered their ballot choices by, for example, hand-marking paper ballots, are generally unable to detect vote manipulation. The implications for future voting system design are also discussed.

INTRODUCTION

The passage of the Help America Vote Act (HAVA)¹ in 2002 and the nearly 4 billion dollars in HAVA funds subsequently disbursed to the states² helped usher in the present era of electronic voting based on computer touchscreens. The authors of HAVA anticipated that voter confidence would be a significant factor in widespread acceptance of computerized voting, and they included a requirement for enabling voter verification of ballot choices before votes are electronically tabulated. Although HAVA requires a voter-verified *paper* audit trail (VVPAT)³, not all voting machines purchased in the years following the law’s enactment printed paper audit trails.⁴⁵⁶

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Voting system vendors and a small but influential group of voting technology enthusiasts argued instead that voters could verify their choices on the touchscreens before submitting their ballots.⁷ That approach, however, violates the cybersecurity redundancy principle responsible for detecting manipulation⁸. Touchscreen displays and electronic records of cast ballots share common modes of failure since they rely on the same memory and computer logic that would be compromised in a successful attack. This lack of independence invalidates any post-election audit that seeks to compare voted ballots with reported election results. To help resolve the question of whether paper is an essential aspect of voter verification, the Auditability Working Group of the Election Assistance Commission (EAC), which HAVA established to oversee implementation, commissioned a study by the National Institute of Standards and Technology (NIST). The resulting 2011 Report⁹ to the EAC was unequivocal in finding that paper records for the recording of votes are necessary: “[We] found no alternative that does not have as a likely *consequence* either an effective requirement for paper records or the possibility of undetectable errors in the recording of votes.”

Paper—hand-marked by a voter in the form of a ballot—is the medium preferred by most experts for recording voter intent, despite a nearly twenty-year campaign by the voting system industry to promote an all-electronic pathway from capturing a digital record of voter intent to tallying and reporting elections results¹⁰. A 2018 report by the National Academy of Sciences¹¹ summarizes the rationale:

A paper ballot-based voting system makes the paper ballot the official “ballot of record” of the voter’s expressed intentions. Other representations (e.g., an electronic representation produced by a scanner) are derivative and are not voter verifiable.¹²

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Nevertheless, many election systems do not regard the ballot marked by the voter as the cast ballot. Some states even rely exclusively on paperless touchscreen systems. In these states, there *are* no voter-marked ballots. However, many other states have converted to new voting machines that use paper ballots, and those that have not will likely do so when they replace their existing systems¹³. Promoted heavily by the voting machine industry, systems that automatically mark ballots in response to touches on a screen are becoming more common. In such systems, software senses screen touches, records them in computer memory, and subsequently prints them as 1D or 2D barcodes on a human-readable paper card (a “ballot summary card”) for voter verification. Once verified, an electronically produced paper ballot barcode is scanned by a mark sensing device, thereby casting a vote. If a voter verifies the human-readable portion of the ballot summary card, the cast ballot is suitable for use as a VVPAT for of audits and recounts¹⁴.

Voter verifiability has always been controversial. A working paper¹⁵ from the MIT/Caltech Voting Project¹⁶ focused on security and usability concerns of touchscreen voting units. This study and related research—whether through experiments, election observations, or the design of auditing protocols that require VVPAT—have left unresolved what seems to us the central problem of VVPAT: “...establish that people can verify their ballots using a paper receipt.”¹⁷ In other words, is the very concept of voter verification of electronically created paper trails meaningful?

ELECTRONIC BALLOT MARKING DEVICES

There is no standard definition of what constitutes a verified ballot. Sometimes, ballot summary cards are the official audit records, but summaries may be difficult for voters to verify because of their length or complexity. It is possible that a clever designer might break voter

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verification into several smaller steps, which would make summaries easier to verify. This paper avoids such speculation by dealing only with voters' recollection of their ballots. Our reasoning is as follows: if voters cannot distinguish between correct and incorrect versions of their own ballots, then verifying summaries or other renderings of those ballots is no less error prone since any such verification necessarily includes recall of prior choices as a prerequisite step.

We limit our study to electronic ballot marking devices (BMD)¹⁸ that use touchscreens to record and print voter choices on paper ballot summary cards. A ballot summary card contains a human-readable summary of the selections made by the voter but not other unselected choices that may have appeared on the ballot. The card may also contain computer-generated marks such as barcodes that encode the official vote and other information that is not in human readable form (see Figure 1). Voters verify these computer-marked summaries and feed them into mark-sense scanners for subsequent tabulation and reporting. Without loss of generality, we assume that the scanners can either sense human readable voter selections or non-human readable encodings of those selections. BMD advocates believe that the act of printing a computer marked ballot summary card and presenting it to the voter for verification before casting the ballot eliminates the need for a hand-marked paper ballot since only a few seconds elapse between the act of voting on the touchscreen and a voter's examination of the printed ballot summary card. Surely, they assert, a voter will be able to recognize and verify that the printed ballot summary of selections is a correct rendering of the intended votes.

This paper describes the results of experiments aimed at determining the extent to which voters recall ballot choices in realistic voting environments and whether such computer generated ballots are appropriate source documents for post-election audits and recounts. The results reinforce prior studies showing that voters are disinclined to review paper trails for

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accuracy^{19 20}. However, the present paper goes further, demonstrating that, to a statistically significant degree, under conditions favorable to recall, even when attempting to verify ballots, voters cannot accurately recall all prior choices and full ballot contents, even if those choices were made only moments before. We do not, in this paper, propose a mechanism responsible for these limitations, although one plausible explanation is that cognitive limitations associated with short term recall and memory errors play a role. The paper concludes with a discussion of the impact these results should have on the design of future voting systems, particularly those BMD systems that print ballot summaries and non-human readable marks, such as bar codes.

STUDY DESIGN

Study 1: Do voters review their ballot summary cards?

Coalition for Good Governance (CGG) volunteers visited two precincts near Gatlinburg, Tennessee (Sevier County) on May 1, 2018, during the county primary election. The county had recently switched to ES&S ExpressVote ballot marking devices that use touch screens for voting and produce ballot summary cards containing scannable barcode votes and information-only human-readable text of the selections (only) on a ballot summary card. A separate optical scanner reads and records the bar coded votes.

The volunteers were asked to observe voting on the touchscreens machines and record the number of seconds each voter spent reviewing the ballot summary card while standing at the voting machine, en route to the scanner, or while standing at the scanner. Volunteers used the stopwatch on their smartphones to measure the number of seconds. The authors recognize that there can be some variability in how the volunteers observed and counted the number of seconds

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voters spent reviewing their ballot summary cards. We did not establish inter-rater reliability, and, for this reason, we regard the results provided below as preliminary.

Study 2: Can voters verify their ballot summary cards?

Before Tennessee's 2018 primary election, two sample ballots were printed for each party, the first showing the correct races and candidates and the second showing certain errors (see Appendix). On the Republican sample ballot for the precinct being observed, the Tennessee House of Representatives 30th District was replaced with the 29th District. County Commission District 8 was replaced with County Commission District 9, and School Board District 8 was replaced with School Board District 9. On the Democratic sample ballot, the Tennessee House of Representatives 30th District Democratic candidate was replaced with the Republican candidates from the same district. County Commission District 8 was replaced with County Commission District 9, and School Board District 8 was replaced with School Board District 9.

On Tennessee's primary election day, August 2, 2018, CGG volunteers visited two polling locations outside of Chattanooga for which the sample ballots were created. The volunteers stood outside a 150 foot radius of the polling location, and as voters left, the volunteers engaged voters to ask if they would be willing to respond to a few questions. If the voter responded with a 'yes,' the volunteer first asked in which primary they had just voted, Republican or Democratic. The volunteer then chose, at random, either the ballot marked with a red 1 or the ballot marked with a red 2. Volunteers were not told in advance which ballot was correct. The respondent's party and the number of the ballot were recorded on a data sheet. The voter/respondent was permitted time to review the ballot, then the volunteer asked the respondent, "Is this the ballot you just voted on?" If the respondent answered in the affirmative, they were thanked, and the survey was terminated. If the respondent answered in the negative,

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they were asked to describe the errors they saw. Upon recording the voter's description, the volunteer thanked the voter, and the survey was terminated.

Study 1 Results

Bearing in mind the limits to the first study of whether voters reviewed their ballot summary cards before inserting them in the scanner, we solicited observations of voter behavior from CCG staff assigned to two polling locations in Sevier County:

- Eighty-seven voters were observed in Sevier County; 46 at one location and 41 in a second location.
- Forty-six voters were observed reviewing their ballot summary cards (52.9%), while 41 did not review their ballot cards (47.1%). Of the 46 who reviewed their ballot cards, 18 were at the first location visited by the volunteers and 28 at the second location.
- The average time spent by the 46 voters who reviewed their ballot cards was 3.9 seconds. (with a standard deviation of 3.8 seconds). The minimum time spent reviewing was one second, and the maximum was 19 seconds. The ballots each contained 18 contests, and it seems unlikely that a quarter-second per contest allowed sufficient time to conduct an effective review²¹.

Study 2 Results

One-hundred three respondents were surveyed. Tables 1 through 3 provide the frequencies (counts) of respondents' party primary, the ballot reviewed, and whether the ballot viewed was the one the respondent had just voted. As shown in Table 1, 68.0% of respondents stated they voted in the Republican primary, and 32.0% stated that they voted in the Democratic primary. Table 2 shows that 60.2% of the sample ballots reviewed were the correct ballot and 39.8% were the incorrect ballot. Out of the 103 respondents, 74.5% stated that the ballot they

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reviewed as the correct ballot, and 25.5% stated that the ballot they reviewed was the incorrect ballot. (Five out of the 103 respondents gave no definitive answer to the question.)

As shown in Table 4, of the 98 respondents who gave definitive answers as to the correctness of the ballot, 59 were shown the correct ballot. Of them, 51 (86.4%) correctly identified the correct ballot while eight (13.6%) misidentified the correct ballot as incorrect (a false negative). Thirty-nine respondents were shown the incorrect ballot, and 17 (43.6%) correctly identified that their ballot was incorrect. Twenty-two (56.4%) incorrectly identified the incorrect ballot as correct (a false positive). A chi-square test indicated that these differences are statistically significant.

Those who identified the incorrect ballot gave the following information when asked what errors they saw on the ballot:

- [Candidate name] 3rd or 4th column
- [Candidate name] missing, [candidate name], School Board
- [Candidate name] was on Dem ballot
- [Candidate name] wrong, [other candidate name]
- [listed three candidates' names], School Board
- [listed three candidates' names]
- 3 or 4, Dist 9
- 30th rather than 29th and one other
- All but [candidate name]
- Don't recognize [candidate name] or the clerks
- House 30th. Most were unchanged
- Just general. I didn't study it
- Missing [candidate name]
- Mostly the same
- Not Registrar of Deeds, School Board
- Republican candidate listed, [candidate name]
- School board
- School Board off
- School Board, [candidate name] District 9
- Some names are Republican and I want to say School Board is incorrect

Discussion

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If voters' memory of their ballots was accurate and their recognition of the sample ballots was correct, 39.8% should have identified that they were viewing the incorrect ballot. Rather, only 25.5% of respondents stated that their ballot was incorrect. Furthermore, 13.6% of respondents mistakenly reported that the correct ballot was incorrect. Such data indicates either that voters' memories of the ballots they voted on were incorrect, or that their recognition of the ballot they were viewing was erroneous. In either case, the high number (more than 55%) of false positives, if observed in actual verifications, indicates that most voters would verify compromised ballot summary cards that misstated the votes cast a few seconds before.

IMPLICATIONS FOR ELECTION SYSTEM AUDITABILITY DESIGN

Because voting technology can be used to create competing evidence of voter intent²², system designers often search for a "gold standard" ballot that can be retained, protected, and analyzed to determine, for example, whether an error or malicious intrusion has corrupted data used to obtain voting results. The principal reason for preferring paper for ballots of record is the difficulty of systematic, malicious attack on a stack of paper, and the creation of a permanent audit trail for verification of results. This advantage of paper ballots is surprisingly controversial, however. One former Georgia Secretary of State has recently testified as to the contrary in Federal Court.²³ Although it seems evident to us that hand-marked paper ballots are the simplest and most reliable way to determine voter intent, others argue that the sordid history of suspect paper- ballot elections²⁴ justifies the consideration of more technologically complex solutions.

These are issues that go well beyond the scope of this paper, but our results are not unrelated. Currently marketed and approved voting technologies require some form of "verifiability" by the voter. If voters are asked to recall prior choices (rather than, say, present

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evidence of those choices in the form of a hand-marked ballot), it is legitimate also to ask whether voters with ordinary cognitive skills can reliably do so and whether voters are likely to attempt to verify their ballots.

The act of marking and presenting a hand-marked paper ballot is a direct expression of voter intent. In the authors' view, no further verification is needed because the self-authenticating paper ballot is an observable signal made by the voter, unfiltered by any intermediate technological filter. Although the voter could have incorrectly signaled a choice, human error is a possible outcome of any methods of voting; such a mistake is attributable to the voter and not to the interference of any third party. The hand-marked ballot is the best evidence of voter intent. Voter verification of an electronically produced paper record is a confirmation of voter intent. It is a kind of test. However, intent is a psychological state and therefore cannot be directly accessed by any verifier. Verification of a ballot summary card involves both willingness to focus on the card after voting, and memory of intent or prior actions. Anyone trying to infer voter intent by asking the voter to verify prior choices runs into two psychological limitations.

The first limitation is that short-term human memory is a scarce cognitive resource. Human beings cannot recall more than a dozen recent information chunks of information²⁵—certainly not the dozens of choices in densely populated counties and precincts, or even the 18 separate contests in Sevier County, Tennessee.

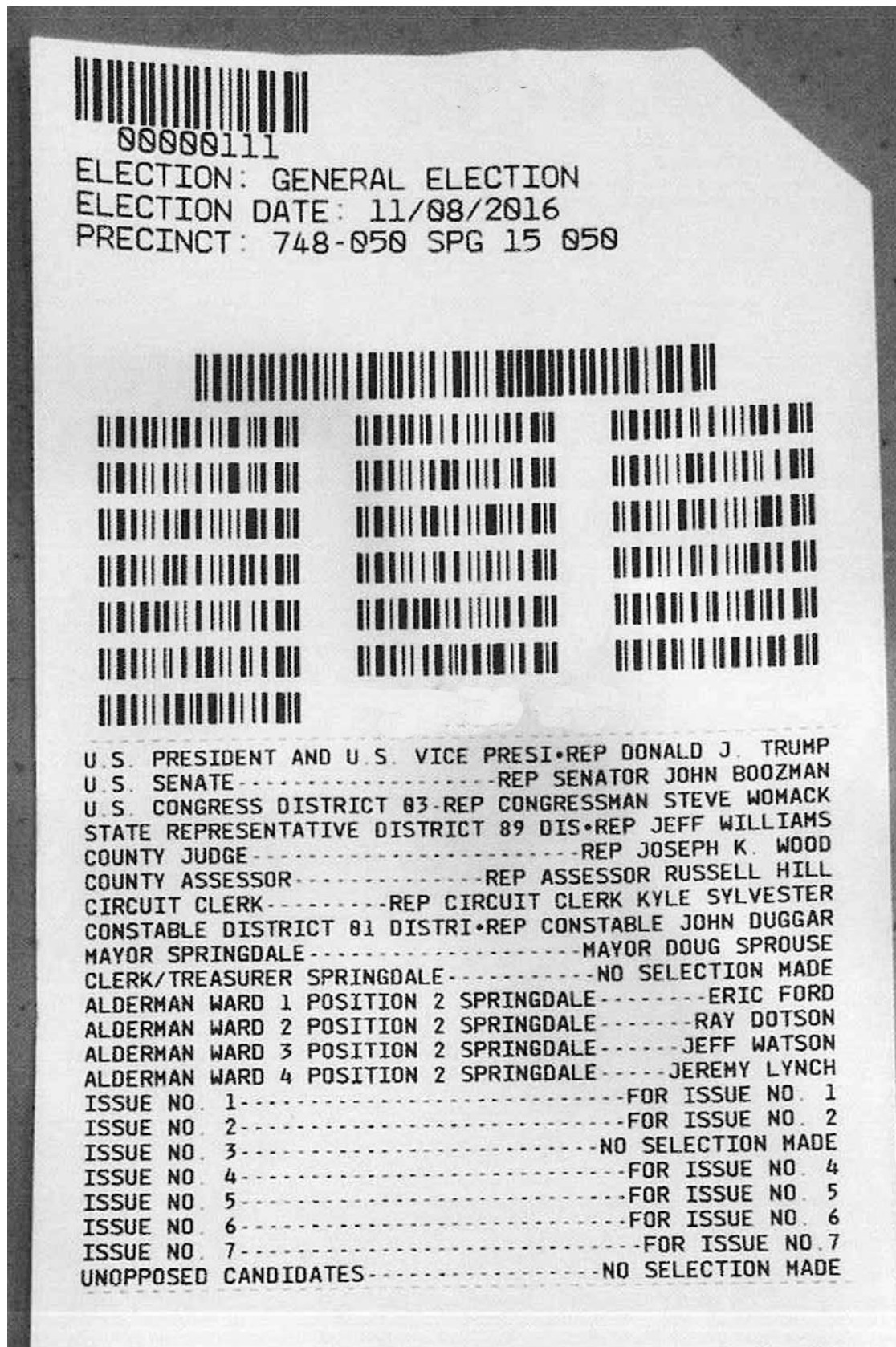
The second limitation is that cognitive biases intrude on a voter's accurate recall of prior choices. Existing methods for voter verification amount to "Here, look at this!" There is no reason to believe that this or any verification protocol would be resilient to availability heuristics or the dozens of possible memory errors caused by priming, misattribution, suggestibility, serial positioning, telescoping, or other effects.²⁶ Given the extent to which test subjects are known to

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insist on the veracity of recollections that are demonstrably false or to agree with an authoritative-sounding description of events that never happened, the use of recall in VVPAT deserves further evaluation.

In a headlong rush to develop new voting technologies, designers may be sidestepping critical questions whose answers affect the safety of election systems. Reducing the readability of ballot summary cards does not increase one's ability to verify. Ballot summary verification is likely to be error-prone, and many popular ballot marking devices compound this problem by attaching marks and codes that are not readable with reasonable effort by ordinary voters. The result is a source document that is not a reliable document for post-election audits.

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00000111

ELECTION: GENERAL ELECTION
ELECTION DATE: 11/08/2016
PRECINCT: 748-050 SPG 15 050

U.S. PRESIDENT AND U.S. VICE PRESI•REP DONALD J. TRUMP
U.S. SENATE-----REP SENATOR JOHN BOOZMAN
U.S. CONGRESS DISTRICT 03-REP CONGRESSMAN STEVE WOMACK
STATE REPRESENTATIVE DISTRICT 89 DIS•REP JEFF WILLIAMS
COUNTY JUDGE-----REP JOSEPH K. WOOD
COUNTY ASSESSOR-----REP ASSESSOR RUSSELL HILL
CIRCUIT CLERK-----REP CIRCUIT CLERK KYLE SYLVESTER
CONSTABLE DISTRICT 01 DISTRI•REP CONSTABLE JOHN DUGGAR
MAYOR SPRINGDALE-----MAYOR DOUG SPROUSE
CLERK/TREASURER SPRINGDALE-----NO SELECTION MADE
ALDERMAN WARD 1 POSITION 2 SPRINGDALE-----ERIC FORD
ALDERMAN WARD 2 POSITION 2 SPRINGDALE-----RAY DOTSON
ALDERMAN WARD 3 POSITION 2 SPRINGDALE-----JEFF WATSON
ALDERMAN WARD 4 POSITION 2 SPRINGDALE-----JEREMY LYNCH
ISSUE NO. 1-----FOR ISSUE NO. 1
ISSUE NO. 2-----FOR ISSUE NO. 2
ISSUE NO. 3-----NO SELECTION MADE
ISSUE NO. 4-----FOR ISSUE NO. 4
ISSUE NO. 5-----FOR ISSUE NO. 5
ISSUE NO. 6-----FOR ISSUE NO. 6
ISSUE NO. 7-----FOR ISSUE NO. 7
UNOPPOSED CANDIDATES-----NO SELECTION MADE

Figure 1. Sample output of ES&S ExpressVote Ballot Marking Device

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Tables*Table 1: Primary that respondent voted in*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Democrat	33	32.0	32.0	32.0
	Republican	70	68.0	68.0	100.0
	Total	103	100.0	100.0	

Table 2: Ballot reviewed

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (correct ballot)	62	60.2	60.2	60.2
	2 (incorrect ballot)	41	39.8	39.8	100.0
	Total	103	100.0	100.0	

Table 3: Is this the ballot you just voted on?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	25	24.3	25.5	25.5
	Yes	73	70.9	74.5	100.0
	Total	98	95.1	100.0	
Missing	-99	5	4.9		
Total		103	100.0		

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*Table 4: Is this the ballot you just voted on? * Ballot reviewed Crosstabulation*

			Ballot reviewed		Total
			1 (correct ballot)	2 (incorrect ballot)	
Is this the ballot you just voted on?	No	Count	8	17	25
		% within Ballot reviewed	13.6%	43.6%	25.5%
	Yes	Count	51	22	73
		% within Ballot reviewed	86.4%	56.4%	74.5%
Total	Count		59	39	98
	% within Ballot reviewed		100.0%	100.0%	100.0%

Chi-sq. = 11.143, signif. $p \leq 0.001$

DeMillo, Kadel, and Marks


November 28, 2018

Appendix: Sample Ballots*Correct Republican Sample Ballot*

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
 August 2, 2018

1

NOTICE TO VOTERS:

TO VOTE: You must darken the oval  to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a **WRITE-IN VOTE**: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE REPUBLICAN PARTY & HAMILTON COUNTY GENERAL ELECTION

Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	School Board, District 8 Vote for One (1)
Diane Black <input type="radio"/>		Bill Hullander <input type="radio"/> (Republican Party Nominee)	Tucker McClendon <input type="radio"/>
Randy Boyd <input type="radio"/>	Emily G. Beaty <input type="radio"/>	Write-in: <input type="radio"/>	David Testerman <input type="radio"/>
Beth Harwell <input type="radio"/>	Write-in: <input type="radio"/>	Sheriff Vote for One (1)	Write-in: <input type="radio"/>
Bill Lee <input type="radio"/>		Jim Hammond <input type="radio"/> (Republican Party Nominee)	
Basil Marceaux Sr. <input type="radio"/>	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Victor Miller <input type="radio"/> (Democratic Party Nominee)	
Kay White <input type="radio"/>	Kyle E. Hedrick <input type="radio"/> (Republican Party Nominee)	Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Circuit Court Clerk Vote for One (1)	
United States Senate Vote for One (1)		Larry L. Henry <input type="radio"/> (Republican Party Nominee)	
Marsha Blackburn <input type="radio"/>	County Mayor Vote for One (1)	Write-in: <input type="radio"/>	
Aaron L. Pettigrew <input type="radio"/>	Jim Coppinger <input type="radio"/> (Republican Party Nominee)	Criminal Court Clerk Vote for One (1)	
Write-in: <input type="radio"/>	Aloyse Brown <input type="radio"/> (Democratic Party Nominee)	Vince Dean <input type="radio"/> (Republican Party Nominee)	
United States House of Representatives, 3rd Congressional District Vote for One (1)	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
Chuck Fleischmann <input type="radio"/>	County Commission, District 8 Vote for One (1)	Juvenile Court Clerk Vote for One (1)	
Jeremy Massengale <input type="radio"/>	Tim Boyd <input type="radio"/> (Republican Party Nominee)	Gary D. Behler <input type="radio"/> (Republican Party Nominee)	
Harold E. Shevin <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
William E. Spurlock, Sr. <input type="radio"/>		County Clerk Vote for One (1)	
Write-in: <input type="radio"/>		W.F. (Bill) Knowles <input type="radio"/> (Republican Party Nominee)	
Tennessee Senate, 11th Senatorial District Vote for One (1)		Write-in: <input type="radio"/>	
Bo Watson <input type="radio"/>		Register of Deeds Vote for One (1)	
Write-in: <input type="radio"/>		Marc Gravitt <input type="radio"/> (Republican Party Nominee)	
Tennessee House of Representatives, 30th Representative District Vote for One (1)		Vickie Schroyer <input type="radio"/> (Democratic Party Nominee)	
Esther Helton <input type="radio"/>		Write-in: <input type="radio"/>	
Jonathan Mason <input type="radio"/>			
Write-in: <input type="radio"/>			
State Executive Committeeman, 10th Senatorial District Vote for One (1)			
Gary Green II <input type="radio"/>			
Kenneth J (Ken) Meyer <input type="radio"/>			
Write-in: <input type="radio"/>			

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Incorrect Republican Sample Ballot

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
August 2, 2018

2

NOTICE TO VOTERS:

TO VOTE: You must darken the oval ☐ to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a WRITE-IN VOTE: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE REPUBLICAN PARTY & HAMILTON COUNTY GENERAL ELECTION


Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	School Board, District 9 Vote for One (1)
Diane Black <input type="radio"/>	Emily G. Beaty <input type="radio"/>	Bill Hullander <input type="radio"/> (Republican Party Nominee)	D'Andre Anderson <input type="radio"/>
Randy Boyd <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Steve Highlander <input type="radio"/>
Beth Harwell <input type="radio"/>	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Sheriff Vote for One (1)	Write-in: <input type="radio"/>
Bill Lee <input type="radio"/>	Kyle E. Hedrick <input type="radio"/> (Republican Party Nominee)	Jim Hammond <input type="radio"/> (Republican Party Nominee)	
Basil Marceaux Sr. <input type="radio"/>	Write-in: <input type="radio"/>	Victor Miller <input type="radio"/> (Democratic Party Nominee)	
Kay White <input type="radio"/>	County Mayor Vote for One (1)	Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>	Jim Coppinger <input type="radio"/> (Republican Party Nominee)	Circuit Court Clerk Vote for One (1)	
United States Senate Vote for One (1)	Aloyse Brown <input type="radio"/> (Democratic Party Nominee)	Larry L. Henry <input type="radio"/> (Republican Party Nominee)	
Marsha Blackburn <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
Aaron L. Pettigrew <input type="radio"/>	County Commission, District 9 Vote for One (1)	Criminal Court Clerk Vote for One (1)	
Write-in: <input type="radio"/>	Chester Bankston <input type="radio"/> (Republican Party Nominee)	Vince Dean <input type="radio"/> (Republican Party Nominee)	
United States House of Representatives, 3rd Congressional District Vote for One (1)	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
Chuck Fleischmann <input type="radio"/>		Juvenile Court Clerk Vote for One (1)	
Jeremy Massengale <input type="radio"/>		Gary D. Behler <input type="radio"/> (Republican Party Nominee)	
Harold E. Shevlin <input type="radio"/>		Write-in: <input type="radio"/>	
William E. Spurlock, Sr. <input type="radio"/>		County Clerk Vote for One (1)	
Write-in: <input type="radio"/>		W.F. (Bill) Knowles <input type="radio"/> (Republican Party Nominee)	
Tennessee Senate, 11th Senatorial District Vote for One (1)		Write-in: <input type="radio"/>	
Bo Watson <input type="radio"/>		Register of Deeds Vote for One (1)	
Write-in: <input type="radio"/>		Marc Gravitt <input type="radio"/> (Republican Party Nominee)	
Tennessee House of Representatives, 29th Representative District Vote for One (1)		Vickie Schroyer <input type="radio"/> (Democratic Party Nominee)	
Mike Carter <input type="radio"/>		Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>			
State Executive Committeeman, 10th Senatorial District Vote for One (1)			
Gary Green II <input type="radio"/>			
Kenneth J (Ken) Meyer <input type="radio"/>			
Write-in: <input type="radio"/>			

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Key to Incorrect Republican Sample Ballot

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
August 2, 2018

NOTICE TO VOTERS:

TO VOTE: You must darken the oval  to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a WRITE-IN VOTE: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE REPUBLICAN PARTY & HAMILTON COUNTY GENERAL ELECTION

Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	School Board, District 9 Vote for One (1)
Diane Black <input type="radio"/>	Emily G. Beaty <input type="radio"/>	Bill Hullander (Republican Party Nominee) <input type="radio"/>	D'Andre Anderson <input type="radio"/>
Randy Boyd <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Steve Highlander <input type="radio"/>
Beth Harwell <input type="radio"/>			Write-in: <input type="radio"/>
Bill Lee <input type="radio"/>	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Sheriff Vote for One (1)	
Basil Marceaux Sr. <input type="radio"/>	Kyle E. Hedrick (Republican Party Nominee) <input type="radio"/>	Jim Hammond (Republican Party Nominee) <input type="radio"/>	
Kay White <input type="radio"/>	Write-in: <input type="radio"/>	Victor Miller (Democratic Party Nominee) <input type="radio"/>	
Write-in: <input type="radio"/>		Write-in: <input type="radio"/>	
United States Senate Vote for One (1)	County Mayor Vote for One (1)	Circuit Court Clerk Vote for One (1)	
Marsha Blackburn <input type="radio"/>	Jim Coppinger (Republican Party Nominee) <input type="radio"/>	Larry L. Henry (Republican Party Nominee) <input type="radio"/>	
Aaron L. Pettigrew <input type="radio"/>	Aloyse Brown (Democratic Party Nominee) <input type="radio"/>	Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Criminal Court Clerk Vote for One (1)	
United States House of Representatives, 3rd Congressional District Vote for One (1)	County Commission, District 9 Vote for One (1)	Vince Dean (Republican Party Nominee) <input type="radio"/>	
Chuck Fleischmann <input type="radio"/>	Chester Bankston (Republican Party Nominee) <input type="radio"/>	Write-in: <input type="radio"/>	
Jeremy Massengale <input type="radio"/>	Write-in: <input type="radio"/>	Juvenile Court Clerk Vote for One (1)	
Harold E. Shevlin <input type="radio"/>		Gary D. Behler (Republican Party Nominee) <input type="radio"/>	
William E. Spurlock, Sr. <input type="radio"/>		Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>		County Clerk Vote for One (1)	
Tennessee Senate, 11th Senatorial District Vote for One (1)		W.F. (Bill) Knowles (Republican Party Nominee) <input type="radio"/>	
Bo Watson <input type="radio"/>		Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>		Register of Deeds Vote for One (1)	
Tennessee House of Representatives, 29th Representative District Vote for One (1)		Marc Gravit (Republican Party Nominee) <input type="radio"/>	
Mike Carter <input type="radio"/>		Vickie Schroyer (Democratic Party Nominee) <input type="radio"/>	
Write-in: <input type="radio"/>		Write-in: <input type="radio"/>	
State Executive Committeeman, 10th Senatorial District Vote for One (1)			
Gary Green II <input type="radio"/>			
Kenneth J (Ken) Meyer <input type="radio"/>			
Write-in: <input type="radio"/>			


Version 2

Correct Democratic Sample Ballot

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
August 2, 2018

1

NOTICE TO VOTERS:

TO VOTE: You must darken the oval  to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a WRITE-IN VOTE: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE DEMOCRATIC PARTY & HAMILTON COUNTY GENERAL ELECTION

Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	Register of Deeds Vote for One (1)
Karl Dean <input type="radio"/>	Khristy Wilkinson <input type="radio"/>	Bill Hullander <input type="radio"/> (Republican Party Nominee)	Marc Gravitt <input type="radio"/> (Republican Party Nominee)
Craig Fitzhugh <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Vickie Schroyer <input type="radio"/> (Democratic Party Nominee)
Mezianne Vale Payne <input type="radio"/>			Write-in: <input type="radio"/>
Write-in: <input type="radio"/>			
United States Senate Vote for One (1)	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Sheriff Vote for One (1)	School Board, District 8 Vote for One (1)
Phil Bredesen <input type="radio"/>	Kyle E. Hedrick <input type="radio"/> (Republican Party Nominee)	Jim Hammond <input type="radio"/> (Republican Party Nominee)	Tucker McClendon <input type="radio"/>
Gary Davis <input type="radio"/>	Write-in: <input type="radio"/>	Victor Miller <input type="radio"/> (Democratic Party Nominee)	David Testerman <input type="radio"/>
John Wolfe <input type="radio"/>		Write-in: <input type="radio"/>	Write-in: <input type="radio"/>
Write-in: <input type="radio"/>			
United States House of Representatives, 3rd Congressional District Vote for One (1)	County Mayor Vote for One (1)	Circuit Court Clerk Vote for One (1)	
Danielle Mitchell <input type="radio"/>	Jim Coppinger <input type="radio"/> (Republican Party Nominee)	Larry L. Henry <input type="radio"/> (Republican Party Nominee)	
Write-in: <input type="radio"/>	Aloyse Brown <input type="radio"/> (Democratic Party Nominee)	Write-in: <input type="radio"/>	
	Write-in: <input type="radio"/>	Criminal Court Clerk Vote for One (1)	
Tennessee Senate, 11th Senatorial District Vote for One (1)	County Commission, District 8 Vote for One (1)	Vince Dean <input type="radio"/> (Republican Party Nominee)	
Randall "Randy" Price <input type="radio"/>	Tim Boyd <input type="radio"/> (Republican Party Nominee)	Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Juvenile Court Clerk Vote for One (1)	
		Gary D. Behler <input type="radio"/> (Republican Party Nominee)	
Tennessee House of Representatives, 30th Representative District Vote for One (1)		Write-in: <input type="radio"/>	
Joda Thongnopnua <input type="radio"/>		County Clerk Vote for One (1)	
Write-in: <input type="radio"/>		W.F. (Bill) Knowles <input type="radio"/> (Republican Party Nominee)	
		Write-in: <input type="radio"/>	
State Executive Committeeman, 10th Senatorial District Vote for One (1)			
Chris Anderson <input type="radio"/>			
Write-in: <input type="radio"/>			


Version 2

Incorrect Democratic Sample Ballot

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
August 2, 2018

2

NOTICE TO VOTERS:

TO VOTE: You must darken the oval  to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a WRITE-IN VOTE: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE DEMOCRATIC PARTY & HAMILTON COUNTY GENERAL ELECTION


Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	Register of Deeds Vote for One (1)
Karl Dean <input type="radio"/>	Khristy Wilkinson <input type="radio"/>	Bill Hullander <input type="radio"/> (Republican Party Nominee)	Marc Gravitt <input type="radio"/> (Republican Party Nominee)
Craig Fitzhugh <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Vickie Schroyer <input type="radio"/> (Democratic Party Nominee)
Mezianne Vale Payne <input type="radio"/>			Write-in: <input type="radio"/>
Write-in: <input type="radio"/>			
United States Senate Vote for One (1)	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Sheriff Vote for One (1)	School Board, District 9 Vote for One (1)
Phil Bredesen <input type="radio"/>	Kyle E. Hedrick <input type="radio"/> (Republican Party Nominee)	Jim Hammond <input type="radio"/> (Republican Party Nominee)	D'Andre Anderson <input type="radio"/>
Gary Davis <input type="radio"/>	Write-in: <input type="radio"/>	Victor Miller <input type="radio"/> (Democratic Party Nominee)	Steve Highlander <input type="radio"/>
John Wolfe <input type="radio"/>		Write-in: <input type="radio"/>	Write-in: <input type="radio"/>
Write-in: <input type="radio"/>			
United States House of Representatives, 3rd Congressional District Vote for One (1)	County Mayor Vote for One (1)	Circuit Court Clerk Vote for One (1)	
Danielle Mitchell <input type="radio"/>	Jim Coppinger <input type="radio"/> (Republican Party Nominee)	Larry L. Henry <input type="radio"/> (Republican Party Nominee)	
Write-in: <input type="radio"/>	Aloyse Brown <input type="radio"/> (Democratic Party Nominee)	Write-in: <input type="radio"/>	
	Write-in: <input type="radio"/>	Criminal Court Clerk Vote for One (1)	
Tennessee Senate, 11th Senatorial District Vote for One (1)	County Commission, District 9 Vote for One (1)	Vince Dean <input type="radio"/> (Republican Party Nominee)	
Randall "Randy" Price <input type="radio"/>	Chester Bankston <input type="radio"/> (Republican Party Nominee)	Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Juvenile Court Clerk Vote for One (1)	
Tennessee House of Representatives, 30th Representative District Vote for One (1)		Gary D. Behler <input type="radio"/> (Republican Party Nominee)	
Esther Helton <input type="radio"/>		Write-in: <input type="radio"/>	
Jonathan Mason <input type="radio"/>		County Clerk Vote for One (1)	
Write-in: <input type="radio"/>		W.F. (Bill) Knowles <input type="radio"/> (Republican Party Nominee)	
State Executive Committeeman, 10th Senatorial District Vote for One (1)		Write-in: <input type="radio"/>	
Chris Anderson <input type="radio"/>			
Write-in: <input type="radio"/>			

Version 2

Key to Incorrect Democratic Sample Ballot

SAMPLE BALLOT
STATE OF TENNESSEE, HAMILTON COUNTY
August 2, 2018

NOTICE TO VOTERS:

TO VOTE: You must darken the oval  to the **RIGHT** of your choice(s) completely. Each contest will indicate how many ovals you may mark.

To case a WRITE-IN VOTE: You must darken the oval completely AND WRITE THE NAME of your choice in the space provided.

STATE DEMOCRATIC PARTY & HAMILTON COUNTY GENERAL ELECTION

Governor Vote for One (1)	State Executive Committeewoman, 10th Senatorial District Vote for One (1)	County Trustee Vote for One (1)	Register of Deeds Vote for One (1)
Karl Dean <input type="radio"/>	Kristy Wilkinson <input type="radio"/>	Bill Hullander <input type="radio"/> (Republican Party Nominee)	Marc Gravitt <input type="radio"/> (Republican Party Nominee)
Craig Fitzhugh <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Vickie Schroyer <input type="radio"/> (Democratic Party Nominee)
Mezianne Vale Payne <input type="radio"/>	Circuit Court Judge, Div. 4 11th Judicial District (Unexpired Term) Vote for One (1)	Sheriff Vote for One (1)	Write-in: <input type="radio"/>
Write-in: <input type="radio"/>	Kyle E. Hedrick <input type="radio"/> (Republican Party Nominee)	Jim Hammond <input type="radio"/> (Republican Party Nominee)	School Board, District 9 Vote for One (1)
United States Senate Vote for One (1)	Write-in: <input type="radio"/>	Victor Miller <input type="radio"/> (Democratic Party Nominee)	D'Andre Anderson <input type="radio"/>
Phil Bredesen <input type="radio"/>	County Mayor Vote for One (1)	Write-in: <input type="radio"/>	Steve Highlander <input type="radio"/>
Gary Davis <input type="radio"/>	Jim Coppinger <input type="radio"/> (Republican Party Nominee)	Circuit Court Clerk Vote for One (1)	Write-in: <input type="radio"/>
John Wolfe <input type="radio"/>	Aloyse Brown <input type="radio"/> (Democratic Party Nominee)	Larry L. Henry <input type="radio"/> (Republican Party Nominee)	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
United States House of Representatives, 3rd Congressional District Vote for One (1)	County Commission, District 9 Vote for One (1)	Criminal Court Clerk Vote for One (1)	
Danielle Mitchell <input type="radio"/>	Chester Bankston <input type="radio"/> (Republican Party Nominee)	Vince Dean <input type="radio"/> (Republican Party Nominee)	
Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	Write-in: <input type="radio"/>	
Tennessee Senate, 11th Senatorial District Vote for One (1)		Juvenile Court Clerk Vote for One (1)	
Randall "Randy" Price <input type="radio"/>		Gary D. Behler <input type="radio"/> (Republican Party Nominee)	
Write-in: <input type="radio"/>		Write-in: <input type="radio"/>	
Tennessee House of Representatives, 30th Representative District Vote for One (1)		County Clerk Vote for One (1)	
Esther Helton <input type="radio"/>		W.F. (Bill) Knowles <input type="radio"/> (Republican Party Nominee)	
Jonathan Mason <input type="radio"/>		Write-in: <input type="radio"/>	
Write-in: <input type="radio"/>			
State Executive Committeeman, 10th Senatorial District Vote for One (1)			
Chris Anderson <input type="radio"/>			
Write-in: <input type="radio"/>			

¹<http://legislink.org/us/pl-107-252>

²<https://www.eac.gov/assets/1/6/EAC%20Report%20to%20Congress%20on%20State%20Expenditures%20of%20HAVA%20Funds%202003-2006.pdf>

³ 52 U.S.C. §§ 20901–21145: (i) The voting system shall produce a permanent paper record with a manual audit capacity for such system. (ii) The voting system shall provide the voter with an opportunity to change the ballot or correct any error before the permanent paper record is produced. (iii) The paper record produced under subparagraph (A) shall be available as an official record for any recount conducted with respect to any election in which the system is used.

⁴ [https://www.eac.gov/assets/1/1/EAC%20Advisory%202005-004%20How%20to%20determine%20if%20a%20voting%20system%20is%20compliant%20with%20Section%20301\(a\).pdf](https://www.eac.gov/assets/1/1/EAC%20Advisory%202005-004%20How%20to%20determine%20if%20a%20voting%20system%20is%20compliant%20with%20Section%20301(a).pdf)

⁵ <https://www.eac.gov/assets/1/6/EAC%20Advisory%20Lever%20Voting%20Machines%202005-005.pdf>

⁶ https://www.eac.gov/assets/1/6/2018_HAVA_Funds_background.pdf

p 57.

⁷ Kim Zetter, “The Crisis of Election Security,” New York Times Magazine, September 26, 2018, <https://www.nytimes.com/2018/09/26/magazine/election-security-crisis-midterms.html>

⁸ Douglas W. Jones, “Auditing Elections,” Communications of the ACM, 47(10), October, 2004, 46-50 <https://dl.acm.org/citation.cfm?doid=1022594.1022622>

⁹ Report of the Auditability Working Group Approved by the TGDC for Transmittal to the EAC on January 14, 2011

¹⁰ Matthew Bernhard and J. Alex Halderman and Ronald Rivest and Poorvi Vora and Peter Ryan and Vanessa Teague and Josh Benaloh and Philip Stark and Dan Wallach, “Public Evidence from Secret Ballots,” Proceedings E-Vote-ID 2017, Bregenz, Austria, October 25, 2017, <https://people.csail.mit.edu/rivest/pubs.html#BHRVx17>

¹¹ Securing the Vote: Protecting American Democracy, <http://nap.edu/25120>

¹² Ibid, p. 43

¹³ Wendy Wiser and Max Feldman, “The State of Voting 2018,” The Brennan Center for Justice, New York University,

https://www.brennancenter.org/sites/default/files/publications/2018_06_StateOfVoting_v5%20%281%29.pdf

¹⁴ The security of such systems depends, among other things, on an assumption that the computer does not also print codes or marks that are not human readable. In some current systems mark sense scanning of ballot receipts is the principle input to downstream software that tallies and reports vote totals. In such cases any non-readable portion of the receipt is a non-observable communication channel that attackers can exploit. This is often the case with systems that scan bar codes (discussed below).

¹⁵ Ted Selker and Jon Goler, “Security Vulnerabilities and Problems with VVPT,” Working Paper 16, November 30, 2008, <http://vote.caltech.edu/working-papers/16>

¹⁶ vote.caltech.edu

¹⁷ ibid

¹⁸ <https://csrc.nist.gov/CSRC/media/Presentations/NIST-VOTING/images-media/Voting-Brady.pdf>

¹⁹ cf. 16

²⁰ Stephen N. Goggin and Michael D. Byrne, An Examination of the Auditability of Voter Verified Paper Audit Trail (VVPAT) Ballots, Rice University, 2007

²¹ Keith Rayner and Monica S. Castelhana, Eye movements during reading, scene perception, visual search, Q J Exp Psychol (Hove), 2009 Aug;62(8):1457-506. doi: 10.1080/17470210902816461. Epub 2009 May 14.

²² See Ref. 5

²³ Curling v. Kemp transcript (Cox testimony)

²⁴ Fabrice Lehoucq, Electoral Fraud: Causes, Types, and Consequences, Annual Review of Political Science Vol. 6:233-256 (Volume publication date June 2003) First published online as a Review in Advance on Feb. 6, 2003 <https://doi.org/10.1146/annurev.polisci.6.121901.085655>

²⁵ Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychological Review, **63**(2), 81-97.

²⁶ Daniel Kahneman, Thinking Fast and Slow, MacMillan, 2011